Bharati Vidyapeeth's
College of Engineering, New Delhi

1964-2014
celebrating
Golden Jubilee
BHARATI VIDYAPEETH
Hon'ble Founder Dr. Patangrao Kadam

APPLIED PHYSICS - I

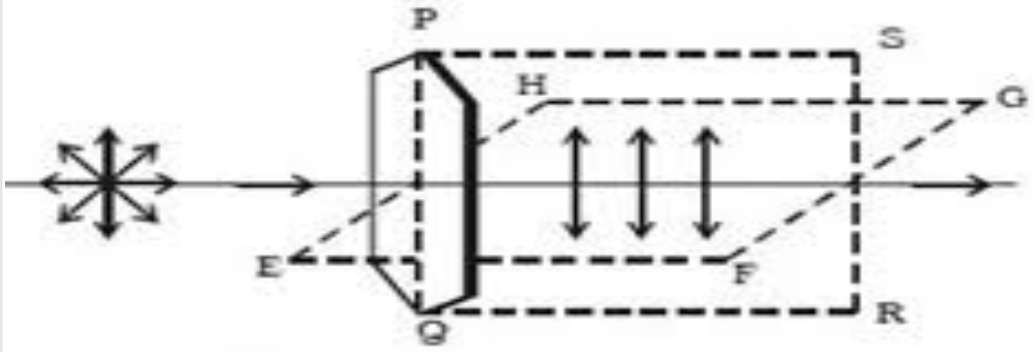
UNIT – III (Polarisation)

- SYLLABUS : : Introduction, Uniaxial crystals, Double refraction, Nicol prism, Quarter and half wave plates, Theory of production of plane, circularly and elliptically polarized lights, Specific rotation, Laurents half shade polarimeter.

Polarization

- A light wave vibrating in more than one plane is referred to as unpolarized light. But if the vibrations of light are restricted to a single plane then this is called polarised light. The process of transforming unpolarized light to polarized light is called Polarization.

Plane of Vibrations and plane of Polarization:



PQRS = Plane of vibration
EFGH = Plane of polarization

The **plane** containing the optic axis in which the **vibrations** occur is known as **plane of vibration**. The **plane** which is at right angles to the **plane of vibration** is known as the **plane of polarisation**.

Types of Polarisation

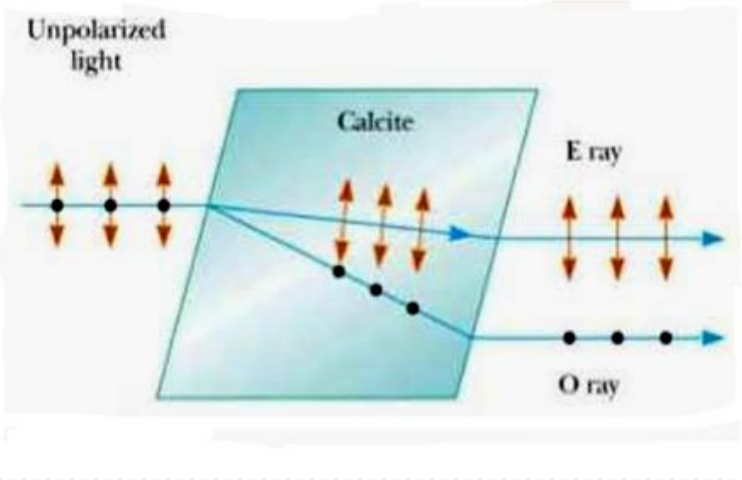
- Plane Polarised Light
- Circularly Polarised light
- Elliptically Polarised Light

Methods to Produce Plane Polarised Light

1. Polarisation by Reflection
2. Polarisation by Refraction
3. Polarisation by Double Refraction (e.g., Nicol Prism)
4. Polarisation by scattering

Double Refraction

- When a beam of ordinary light is incident on an anisotropic material(calcite , quartz etc) it splits up into two polarized refracted rays (O ray and E ray) . This phenomenon is called double refraction.



Double Refraction

- In case of calcite $\mu_o > \mu_e$

  Extraordinary ray moves faster than ordinary ray.
  So Calcite is a uniaxial negative crystal.

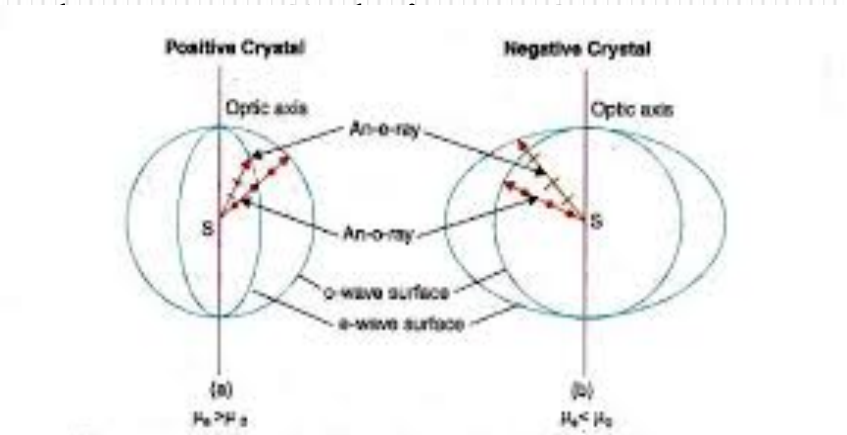
- In case of Quartz $\mu_o < \mu_e$

  Extraordinary ray moves slower than ordinary ray.
  So Quartz is a uniaxial positive crystal.

  - Difference of refractive indices of ordinary and extraordinary rays is called *birefringence*.

Optic Axis and Uniaxial Crystal

- A class of crystals such as calcite , quartz etc. in which there is a single direction (optic axis) along which all waves are travelled with uniform velocity are called uniaxial crys .

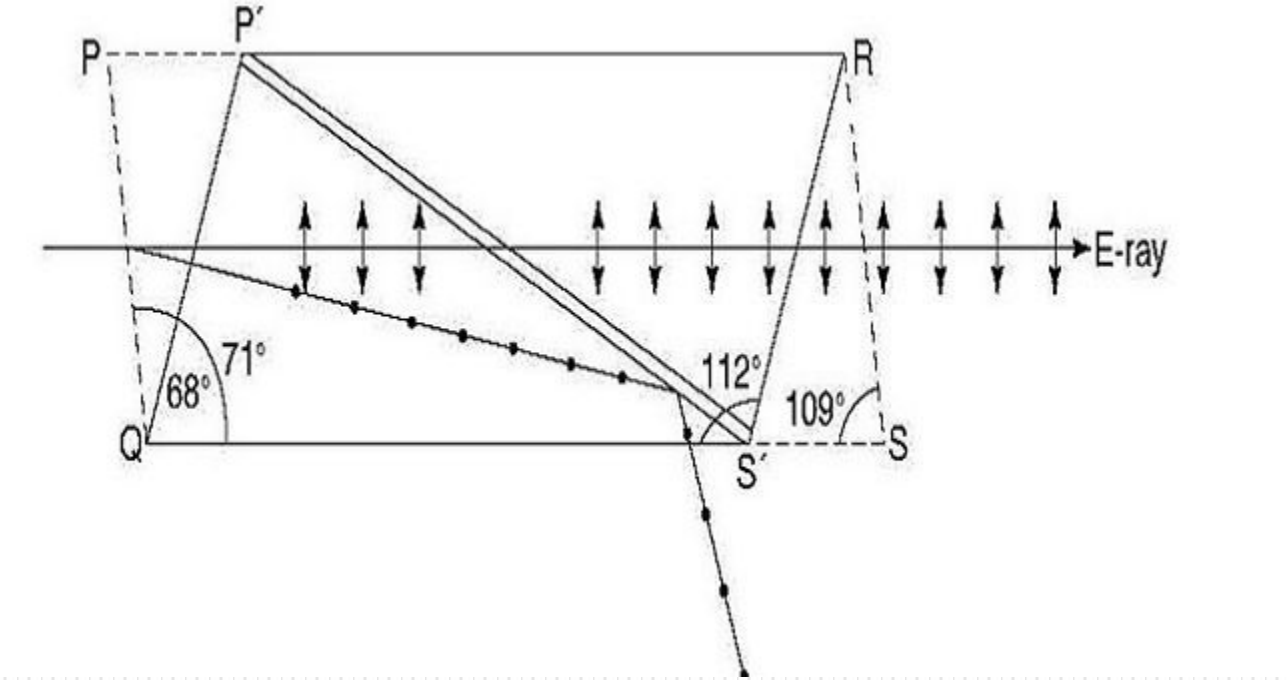


Huygens wave surfaces produced by a point source S embedded in the birefringent crystal; (a) a positive crystal (b) a negative crystal.

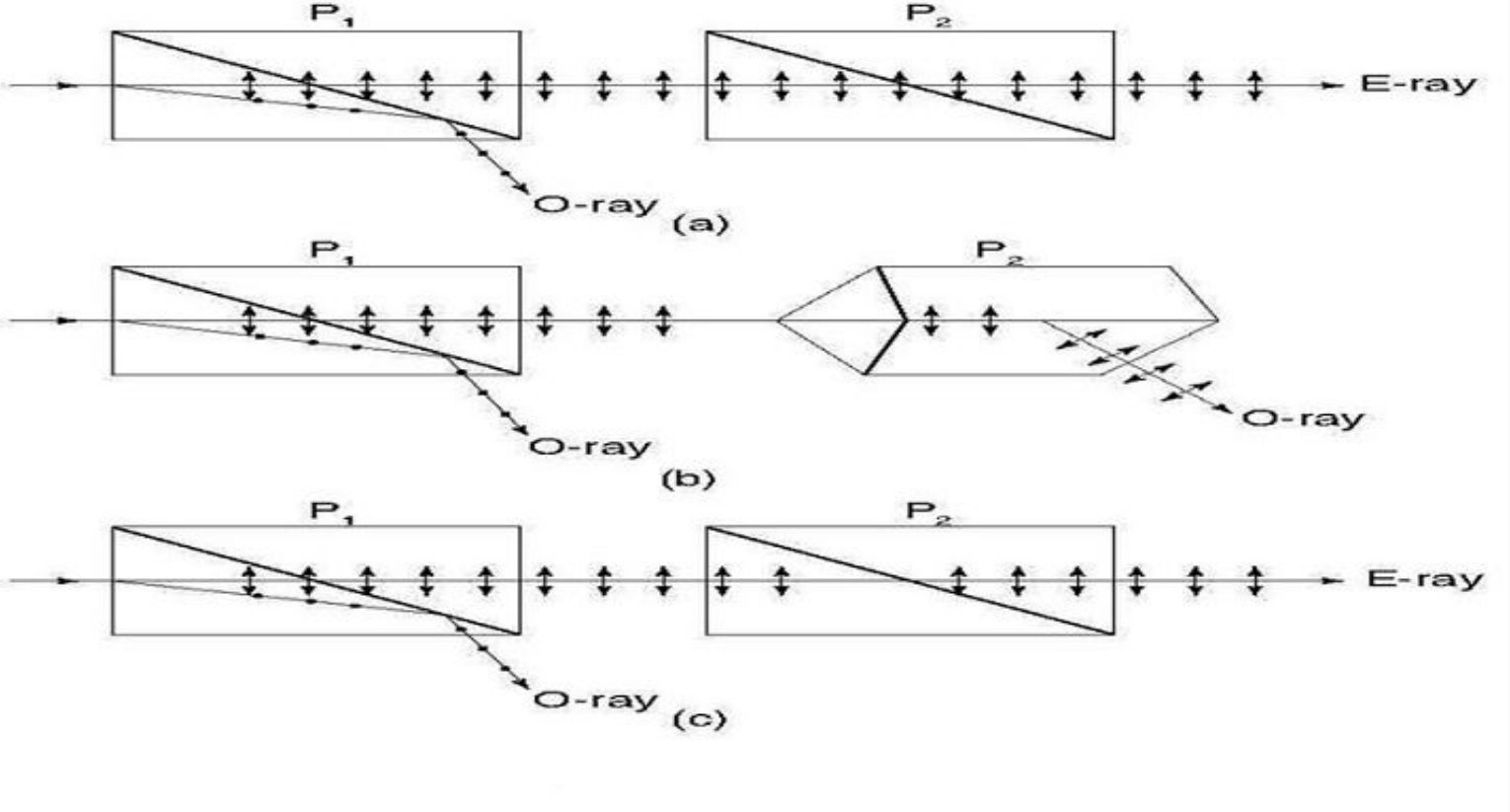
Nicol Prism

- It is a device used to produce and analyze plane polarized light.
- Made of Calcite
- Based on the principle of Double refraction.
- Its length is thrice its breadth.
- Its end faces are cut in such a way that the angles of principal section becomes 68 and 112 degrees.
- The crystal is cut diagonally and pasted with canada balsam (refractive index = 1.526).

Polarizing action of Nicol



Analyzing action of Nicol



Quarter Wave Plate

- It is a plate of doubly refracting crystal with refracting faces cut parallel to optic axis and its thickness is such that it produces a path difference of $\lambda/4$ between ordinary and extraordinary waves.
- The thickness of quarter wave plate for negative crystal is

$$t = \lambda/4\ (\mu_o - \mu_e)$$

- It is used to convert plane polarised light into circularly and elliptically polarized light.

Half Wave Plate

- It is a plate of doubly refracting crystal with refracting faces cut parallel to optic axis and its thickness is such that it produces a path difference of $\lambda/2$ between ordinary and extraordinary waves.
- The thickness of half wave plate for negative crystal is

$$t = \lambda/2\ (\mu_o - \mu_e)$$

- It is used to rotate the plane of polarisation of plane polarised light.
  - QWP and HWP also known as retardation plates.

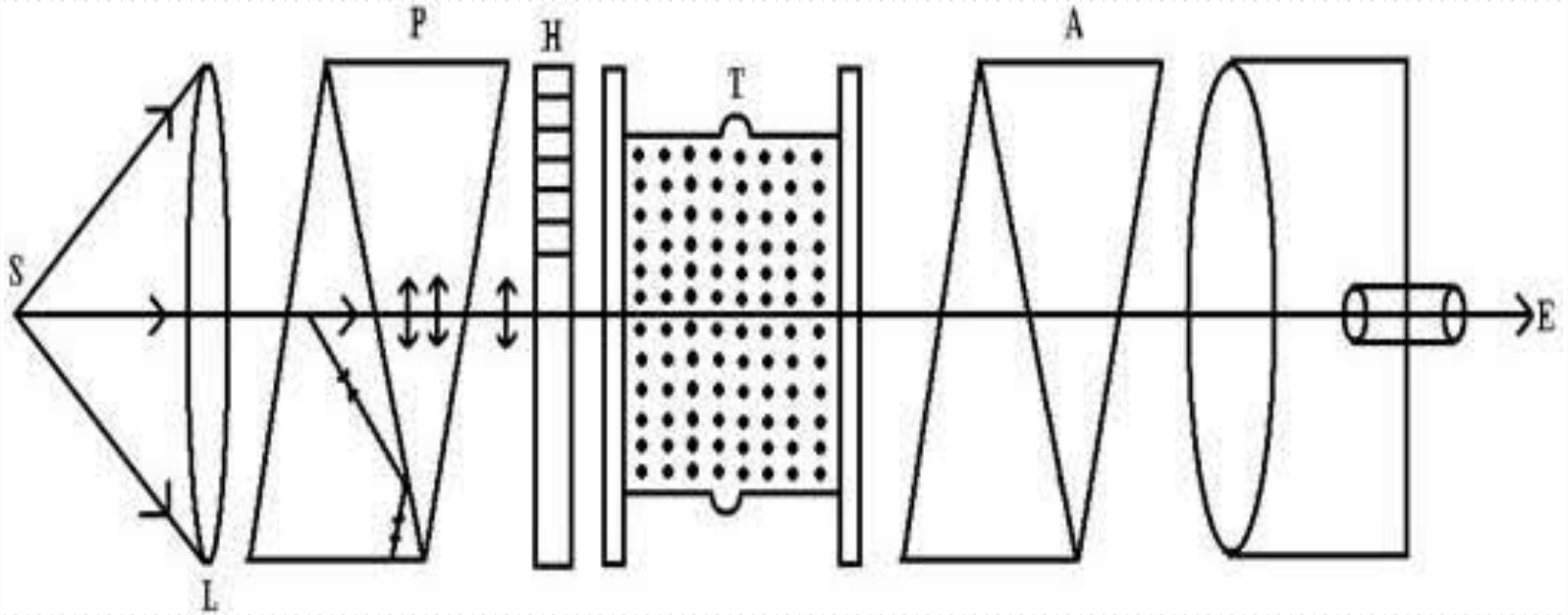
Optical Activity and rotation

- There are certain substances which rotate the plane of polarization when polarized light is passed through them. Such substances are called optically active substances.
- The phenomenon/property is called optical activity.
- The angle through which the plane of polarization is rotated is called optical rotation (α).

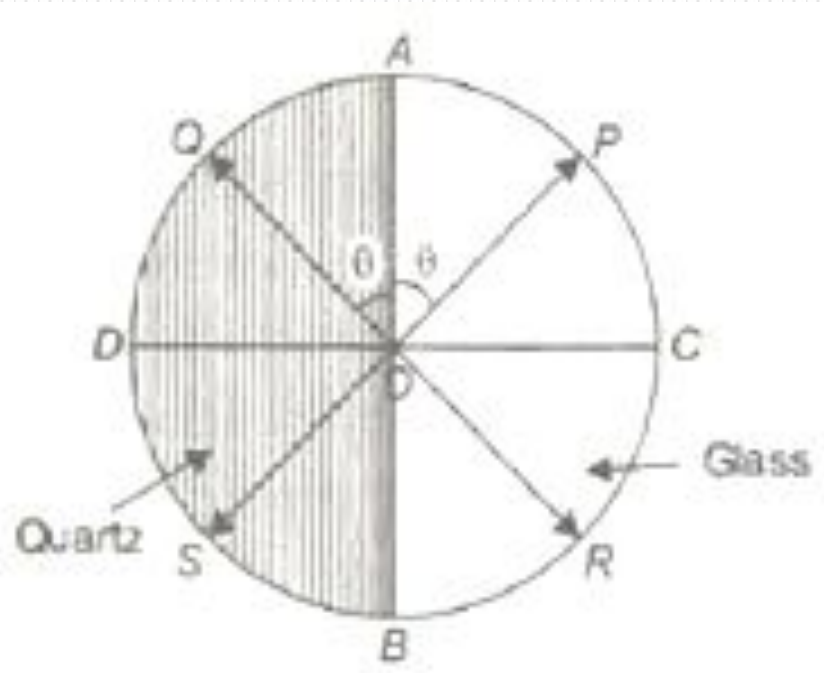
Specific rotation

- Specific Rotation is used to bring the rotation of all optically active substance into a comparable form.
- For solids $S = \alpha/L$ where α is the optical rotation and L is the length of solid in mm.
- For solutions $S = \alpha/LC$ where L is length of soln. in dm and C is the concentration in gm/cc.

Laurent's Half shade polarimeter



Working



- The half-shade H goes between the polarized light source and the sample, and it consists of two half-disks of equally absorptive material. One half, ACB, is glass, and it lets the polarized light pass through unchanged. The other half, ADB, is made of quartz, with the optical axes along AOB and DOC, and it is cut to half-wave-plate thickness; in essence, this means that if the original polarization was along SOP, in the quartz half it gets reflected over into ROQ, i.e. orthogonal to SOP.

. To find specific rotation of an optically active substance the analyzer is adjusted to obtain the condition of equal brightness of both the halves in field of view with water and optically active substance. The difference of both readings of analyzer gives the optical rotation produced by the solution .